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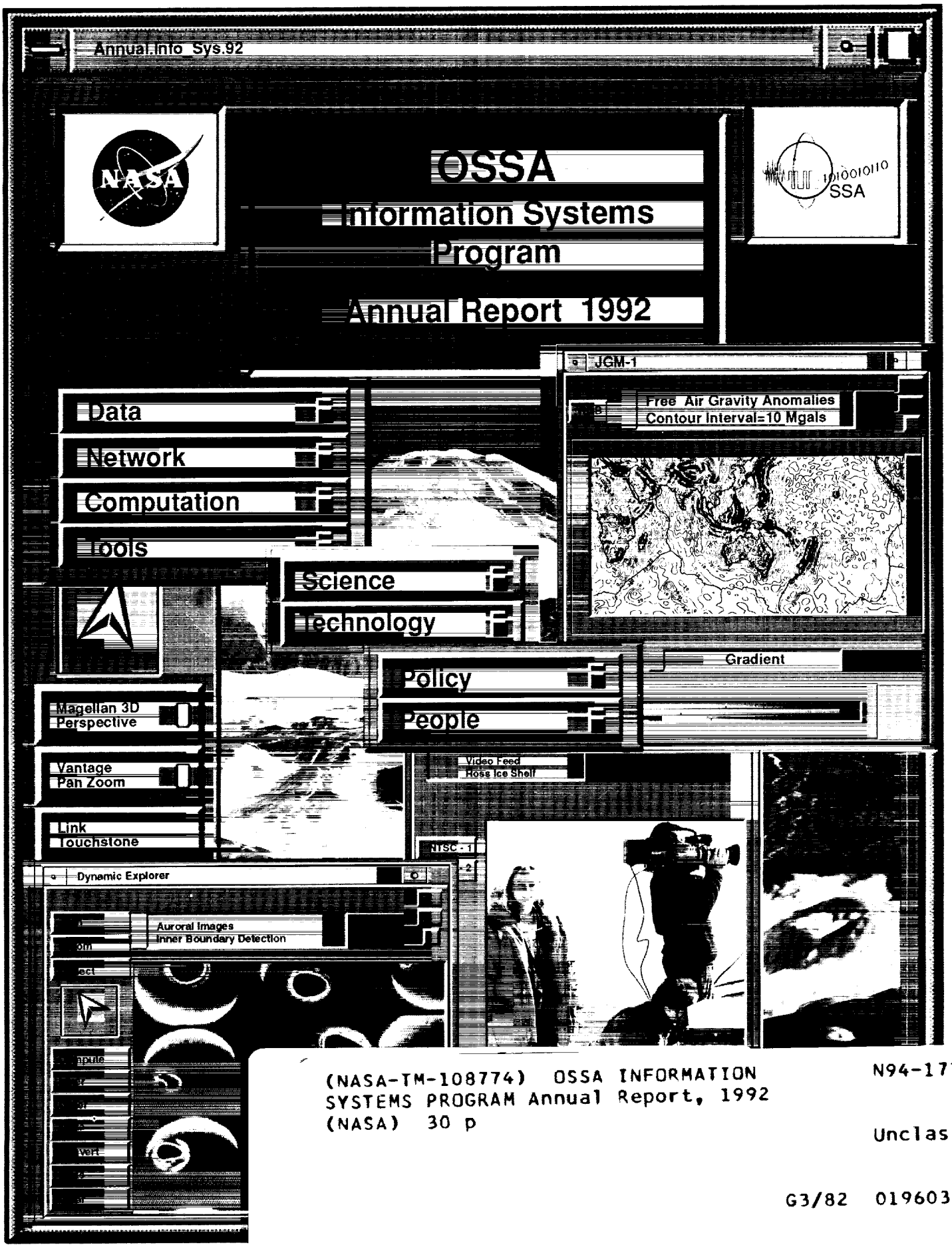

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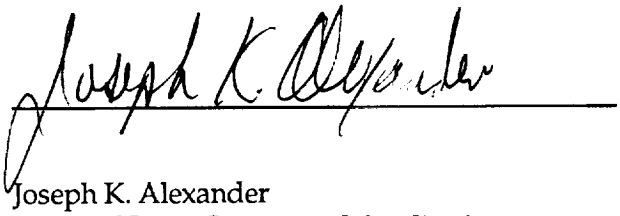
OSSA
Information Systems Program

Annual Report 1992

Preface

The Office of Space Science and Applications' Information Systems Program has proven itself to be an increasingly valuable asset to our science operations and research. Through systematic enhancements in capability along with improved coordination of discipline specific systems and OSSA's information systems infrastructure, the program has enabled increased efficiency and performance. The improved coordination has been a major goal of the Information Systems Management Board, which represents all of OSSA's divisions. The board provides guidance and direction, and establishes a forum for resolution of information systems issues. The work described in this Annual Report represents the efforts of a strong intercenter team of dedicated computer scientists, engineers, and researchers. Through their shared vision and dedication, we are reaping the rewards of enhanced capabilities in computation, data management, and networking.

The years ahead pose great challenges for NASA as a whole, as we deal with the prospect of a constrained budgetary environment. It will be activities like this one that will provide the increasing productivity and efficiency required to meet the ever growing demands of tomorrow's research endeavors.



Joseph K. Alexander
Office of Space Science and Applications
Assistant Associate Administrator for Science and Applications
Chairman, Information Systems Management Board

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Program Overview

"a growing base of integrated information services supporting an expanding, distributed OSSA research community"

The OSSA Information Systems Program was established to coordinate and enhance activities that support the processing, analysis, transport, archival, and access of space science data. Within OSSA, the science discipline divisions have the ultimate responsibility for the proper management of the data generated by their missions. The OSSA Information Systems Branch works in concert with the divisions to provide an infrastructure of information system services and expertise in operations, policy, planning, and technology. Discipline specific and infrastructure activities are coordinated through participation in the OSSA Information Systems Management Board.

The Information Systems Program is organized into four program areas: Scientific Computing, Networking, Data Management and Archiving, and Applied Information Systems Technology. Together, these program areas form a solid technical and policy development base that supports the overall OSSA information systems strategy. The underlying theme of each element is to facilitate science research and ensure the efficient implementation and utilization of OSSA information systems resources.

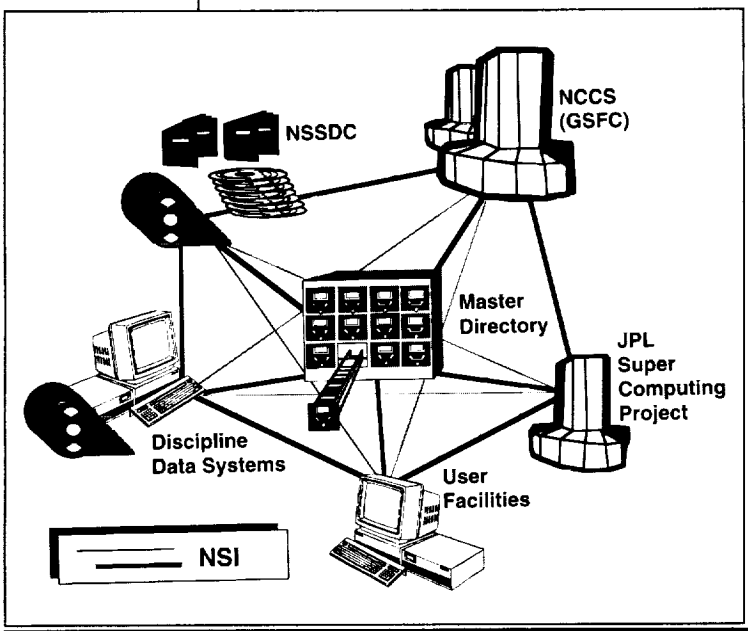


Figure 1:

OSSA information systems resources network

This year has been marked by a growing base of integrated information services supporting an expanding, distributed OSSA research community. Exciting technology developments are enabling new approaches to solving problems. There is also an increased emphasis on achieving efficiencies in the procurement and operation of information systems. The program has effectively accommodated the needs of the OSSA science user within a constrained budgetary environment and has had a positive impact on OSSA's achievement of its overall goals.

One of the most exciting activities this year has been the release of the High Performance Computing and Communications (HPCC) Earth and Space Science NASA Research Announcement and subsequent selection of investigators. This solicitation was made jointly with the NASA Office of Aeronautics and Space Technology as part of NASA's participation in the HPCC program. The quality of the proposals was extremely high and the program promises to bring together some of the best and brightest in space science and computational research to produce breakthroughs in scientific discovery and technology.

Looking to the future, it is clear that the importance of information systems to the achievement of OSSA's goals will only increase. New missions are producing more data than ever and NASA has a commitment to preserve our existing space science data sets as valuable resources for research. Computational demands and capabilities are also growing and our advances in this area are key to unlocking the mysteries of our own world and the universe around us. Computer networks make information services almost instantly accessible to the science community and promote collaboration among scientists. OSSA is committed to continuing its efforts to provide technologically advanced, cost effective systems for the support of its users in the years to come.

Scientific Computing

"a balanced environment that includes supercomputers, mainframes, workstations, data storage, and networks and is readily accessible to the user community "

The Scientific Computing Program provides OSSA researchers with access to computational resources for science research. The program manages the Jet Propulsion Laboratory (JPL) Supercomputing Project and the NASA Center for Computational Sciences (NCCS) at the Goddard Space Flight Center (GSFC), which provide supercomputing and associated resources to the OSSA community (Figure 2). The NCCS operates a four processor Cray Y-MP and an IBM 9021 processor. The JPL supercomputing program hosts a single processor Cray Y-MP. Both facilities provide robotically controlled tape silos, other tape and disk mass storage, high speed and wide area network connectivity, software support, and visualization capabilities. The goal of the program is to provide a balanced environment that includes supercomputers, mainframes, workstations, data storage, and networks and is readily accessible to the user community.

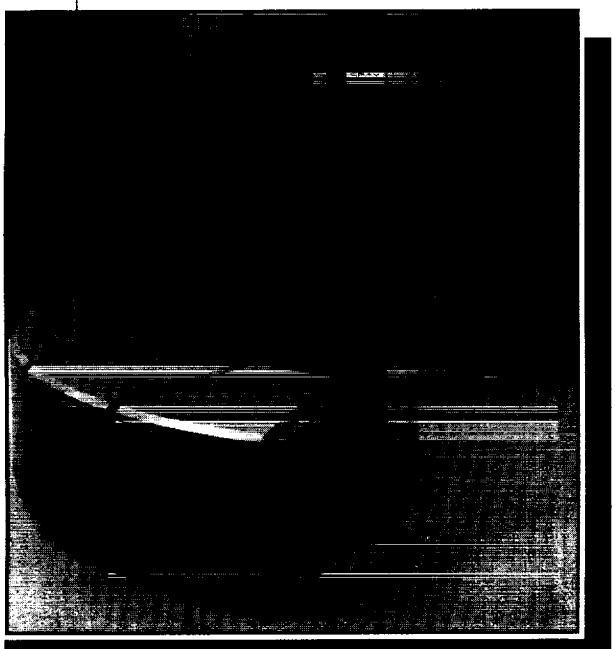


Figure 2:

Cray Y-MP's are in use at the GSFC and JPL computing facilities

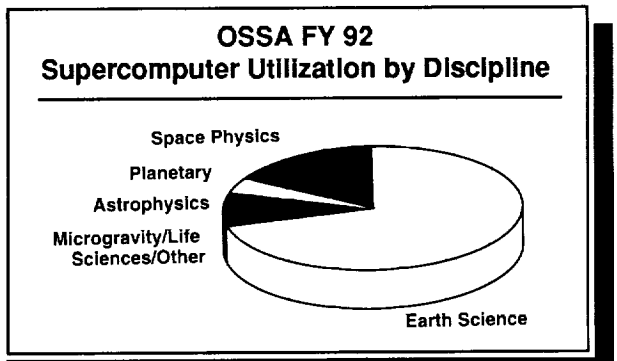


Figure 3:

OSSA Provides supercomputing resources to users in each major science discipline at locations across the country

In 1992, the Scientific Computing Program delivered the equivalent of 39,879 Cray Y-MP hours to OSSA users. For comparison, one Cray Y-MP hour is roughly equivalent to 32,250 hours, over three and a half years, of processing on an IBM AT personal computer. The simulations associated with the development of the Joint Gravity Model 1, described in the next section, required approximately 1000 Cray Y-MP hours of processing. The OSSA supercomputer user community includes researchers from each of the OSSA science divisions at NASA centers, universities, and private industry. The distribution by discipline is given in Figure 3.

As part of the planning efforts in 1992, a user survey was conducted to assess the needs of OSSA's research community through the next five years. Figure 4 illustrates the projected demand and capacity in normalized units of equivalent Cray Y-MP processors. The capacity reflects the resources that we expect to provide under current budget guidelines. OSSA will continue to emphasize the prioritization of requirements across the OSSA science community and increase the productivity and efficiency of existing and planned resources to meet user demands.

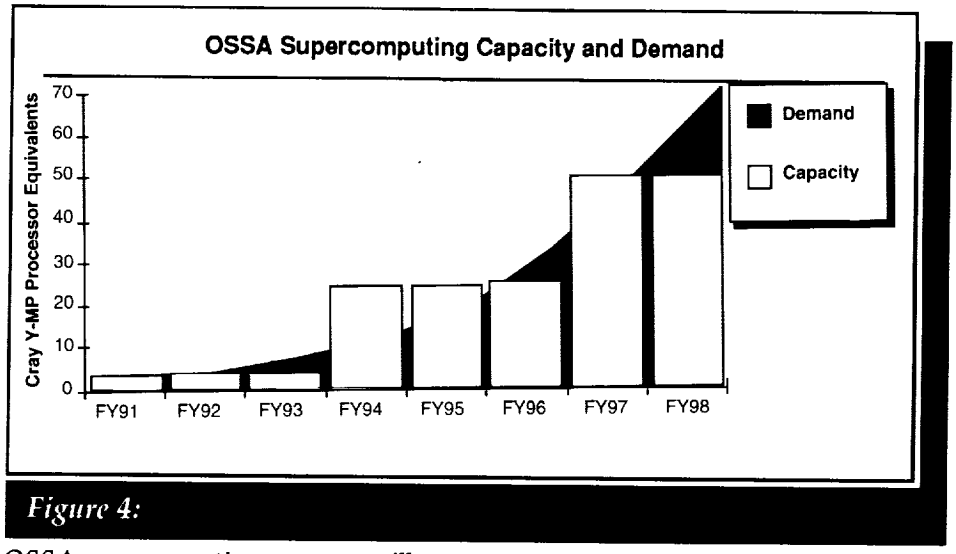


Figure 4:

OSSA supercomputing resources will grow to meet user demands throughout the 1990's

"Emphasis on the prioritization of requirements and increasing the productivity and efficiency of existing and planned resources"

To keep pace with rapidly increasing user needs, several upgrades to hardware and software have been introduced at the computing centers. Significant system upgrades for this year include the completion of the on-line Mass Data Storage and Distribution System (MDSDS) at the NCCS. The MDSDS is a multivendor hardware and software system based on multiple StorageTek 1.2 terabyte robotic tape silos (Figure 5) and Unitree data management software. The system can handle 32 simultaneous sessions with 200 megabyte file sizes. The NCCS has also added over a terabyte of local data storage to its Cray Y-MP by dedicating a StorageTek silo to that task. This year, JPL upgraded its previous generation Cray X-MP to the current Y-MP. JPL also upgraded its data storage system and now has one half of a StorageTek silo dedicated to the Cray Y-MP.

In the area of networking, both the GSFC and JPL computing centers saw enhanced capabilities added this year. The NCCS has achieved end-to-end throughput of over 28 Mbps using Fiber Distributed Data Interface (FDDI) local area networks (LANs) between two

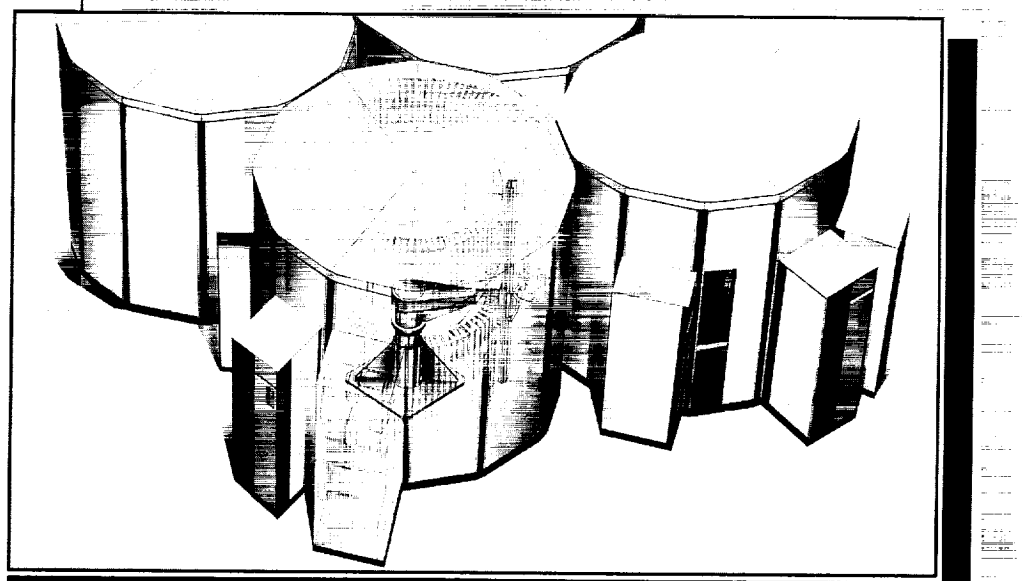


Figure 5:

Robotic tape silos provide massive on-line data storage for OSSA supercomputers

workstations. The computing center has also made initial connection between the FDDI and the 800 Mbps Ultranet to transfer files between workstations and the Cray. At JPL, the distributed parallel programming environment EXPRESS has been successfully tested between Sun workstations, the JPL Cray, an Intel Touchstone Delta parallel processor at Caltech, and a Cray at the San Diego Supercomputing Center. FDDI and High Performance Parallel Interface networks have been installed and are being tested, with full operational capability expected in early 1993. In addition to these network technologies, the program is closely watching the development and application of Synchronous Optical Network (SONET) and Asynchronous Transfer Mode (ATM) technologies through NASA's participation in HPCC and is poised to apply these technologies to further enhance productivity and accessibility.

NASA participation in the Earth and Space Sciences (ESS) portion of the HPCC program is an important component of the OSSA scientific computing program. The goal of ESS is to accelerate the development and application of high performance parallel computing technologies to meet the needs of the U.S. Earth and space science community. Consistent with this goal, OSSA is developing algorithms and architecture testbeds capable of fully utilizing massively-parallel concepts, creating generalized software environments for massively parallel computing applications, and demonstrating the impact of these technologies on NASA research in the Earth and space science physical phenomena. The HPCC program is a partnership between computer scientists and space scientists, and their close interaction will ensure the development of cutting edge technological performance with real world applications.

The explosive growth in computational sciences and technology and the increasing demand for computational resources require the Scientific Computing Program to plan carefully during the coming years, adapting to changes in both technology and scientific methodology. To prepare for these changes, the program has begun development of an OSSA Strategic Plan for Scientific Computing. This plan will address the balance between computing power, networks, mass storage, and visualization; the balance between supercomputers, mainframes, and workstations; centralized vs. distributed computing; the role of parallel architectures in hardware and software; and other key issues for the future of OSSA computing.

"The HPPC program is a partnership between computer scientists and space scientists, and their close interaction will ensure the development of cutting edge technological performance with real world applications"

Highlights

OSSA-sponsored scientific computing centers at GSFC and JPL provide a broad range of services that enable researchers to solve computationally intensive problems. The research activities described below represent only a small portion of the broad spectrum of investigations supported by OSSA, and are provided to give a sense of the types of applications currently being developed. These researchers were provided assistance with code development and conversion, computer training, and scientific visualization as part of OSSA's comprehensive suite of computational support services.

Joint Gravity Model 1

Researchers at GSFC and the Center for Space Research at the University of Texas at Austin used OSSA supercomputing resources to produce a new model of the Earth's gravitational field, Joint Gravity Model 1 (JGM-1), as shown in Figure 6. JGM-1, developed using nearly 1000 Cray Y-MP hours, is complete to degree 70 in spherical harmonics. It represents a significant improvement over previous models, developed on an IBM 3081 and a Cyber 205, which were complete to degree 36 and 50, respectively. The JGM model has largely been developed to support precision orbit determination for the TOPEX/Poseidon mission, but the model is general in nature and should represent the best long wavelength model of the gravity field currently available.

This model was derived from a combination of satellite tracking data, satellite altimeter data (Geos-3, Seasat, Geosat), and surface gravity data (supplied by Ohio State University). JGM-1 will be used for the preliminary orbit computations for TOPEX/Poseidon during the verification period.

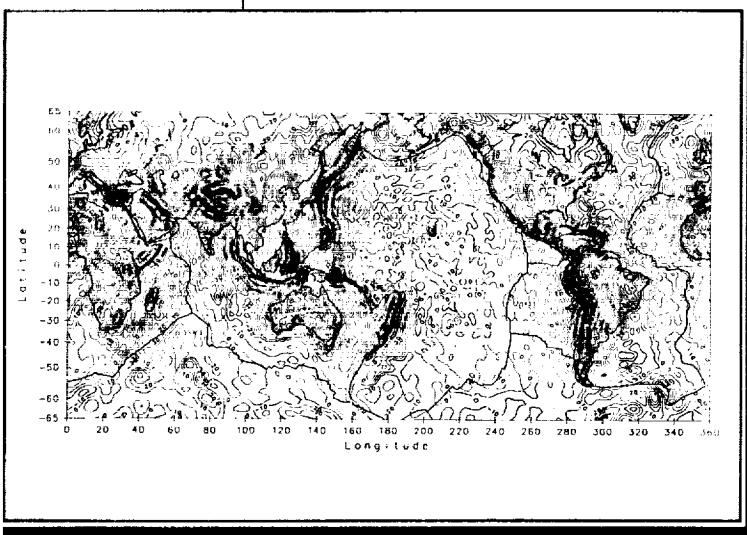


Figure 6:

Higher performance OSSA computational resources are enabling more precise solutions to more complex problems.

Stratospheric General Circulation with Chemistry Project

The Stratospheric General Circulation with Chemistry Project (SGCCP) is a long term proposal to study the general circulation and chemistry of the atmosphere. The present focus is on the stratospheric ozone layer, but future research will include problems specific to the troposphere. Three-dimensional models are used for this study.

The SGCCP is unique in its use of stratospheric data assimilation to derive wind and temperature fields for transport studies. This circumvents some of the biases seen in climatological general circulation models. This approach provides the most realistic representations of stratospheric transport that have been achieved. Recently, the models have been used to address issues of northern hemispheric ozone depletion and anomalous nitric acid chemistry.

Special data assimilation techniques have been used to aid researchers in the study of ozone miniholes. Miniholes are not caused by chemistry. They are caused by dynamic uplifting of the lower stratosphere associated with tropospheric weather systems. Irreversible horizontal transport that accompanies these systems can transport polar air to subpolar latitudes. The polar air can be highly perturbed by chemical processes in the polar night, and has the potential to enhance ozone destruction.

The realistic transport model obtained in this research effort has spawned several other studies. Most notably, the model supports efforts to assess the environmental impact of a proposed fleet of atmospheric aircraft. Understanding the transport of pollutants back to the troposphere is critical for this problem, and the assimilation transport method provides one of the best quantitative approaches to the problem. The transport studies also provide a unique evaluation of assimilated data products for climate applications. Climate applications of data assimilation are a key component of future NASA missions including EOS.

Particle Simulations of the Solar Wind Termination Shock

At JPL and Caltech, researchers have been using advanced architecture machines to study the solar wind. The solar wind plasma expands supersonically throughout and beyond the solar system, creating the extended atmosphere of the Sun called the heliosphere. Beyond the planets, the solar wind interacts with the interstellar medium—the solar wind termination shock is part of this interaction. At this shock, the solar wind makes a transition to subsonic flow. The termination shock occurs when the solar wind pressure has decreased to the level of the interstellar pressure—expected at 80-100 AU (vs. Pluto~40 AU). The Voyager and Pioneer spacecraft may soon encounter this shock. Researchers study the structure of the shock to help predict and interpret what these spacecraft will observe. The solar wind has two components: background thermal solar wind and energetic interstellar "pickup" ions. Pickup ions originate from interstellar neutrals that enter the heliosphere, become ionized and are swept up by the solar wind flow.

The particle simulations illustrate the effect of these interstellar pickup ions on the structure of the solar wind termination shock. They also study how the shock gives these pickups more energy, possibly creating cosmic rays. In the simulation, researchers compute

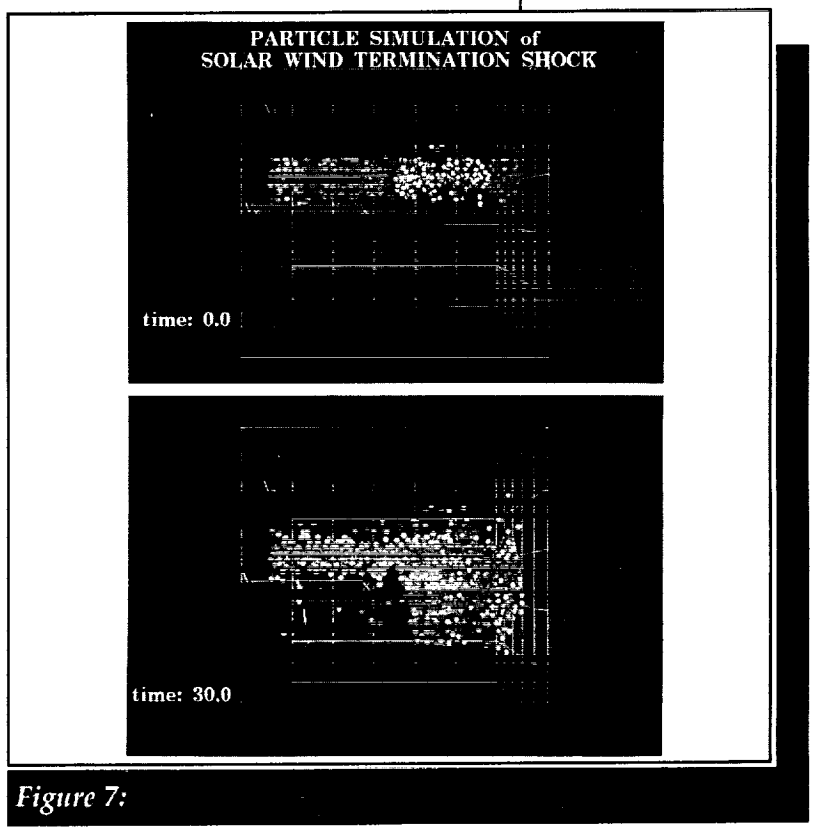


Figure 7:

Visualizations such as this help researchers understand physical processes

orbits of ions moving in electromagnetic fields. On the Intel Touchstone Delta at Caltech, the particle computations are divided among processors. Figure 7 shows ion phase space from the shock simulations—each sphere plots the position (x) and two velocities (vx,vy) of the ions. The solar wind enters the simulation box from the left—the shock is at the interface between the low density region on the left and the high density region on the right. The pickups are preferentially "reflected" by the shock and move back upstream, towards the left, gaining energy in the process. Such energetic reflected ions can be detected by the spacecraft and may give us advanced warning that the spacecraft is about to cross the termination shock.

Dynamic Interactions of Large, Highly Charged Space Platforms with the Ionospheric Plasma

The flight of large space structures in the ionosphere raises the need for a careful analysis of the disturbances induced by large, highly charged objects using computer particle simulations. Researchers at JPL have made a general study of time dependent interactions induced by future space platforms such as the EOS and space station solar array. To date they have focused on the formation and structure of the plasma wake.

Previous studies have concluded that the wake of a large object is created primarily by the body of ions sweeping out from the plasma and leaving a void region behind. While such a picture is true for a plate with low voltages, it was found that at high voltage the plate will generate a space-charge wake characterized by two ion streams embedded in a quasi-neutral wake.

An analysis based on previous theories would conclude that no ions would be collected from the wake-side surface. Results show that such a conclusion is not generally true. Whether the wake-side surface collects current depends on the wake structure. Hence, an accurate charging and grounding calculation for large high-voltage space platforms must be based on a self-consistent solution of the space-charge wake.

Networking

"reliable communications access to colleagues, mission data archives, and computational facilities throughout NASA Centers and research institutions worldwide"

The NASA Science Internet (NSI) was established in 1988 and is managed and operated by the NSI office at Ames Research Center (ARC). NSI provides leading-edge communications networking to flight projects and research programs. NSI gives NASA's authorized principal investigators and discipline scientists reliable communications access to colleagues, mission data archives, and computational facilities throughout NASA Centers and research institutions worldwide. To achieve cost efficiencies, NSI connects, consolidates, and leverages existing networks. NSI is a critical element of OSSA's information systems infrastructure, recognized by users as essential for NASA's continued successful leadership in space science research.

NSI directly connects 4,500 hosts and 300 institutions worldwide using hundreds of routers deployed globally to handle NASA science traffic. NSI is a major participant in the Internet community and interoperates with other federal networks such as the National Science Foundation's NSFNET and the Department of Energy's ESNET, as well as several thousand regional research and education networks, which when combined further extend NSI's reach to over 250,000 host computers and 2 million users worldwide. NSI interoperates with major international research networks in Europe, Japan, and throughout the Pacific. NSI spans all time zones and extends as far north as Greenland and as far south as Antarctica.

NSI is a multiprotocol network using TCP/IP and DECnet protocols. It supports a broad range of computers from desktop MACs and PCs, to high-performance workstations and supercomputers. The NSI Network Operations Center (NOC) at the ARC (Figure 8) operates and monitors the network backbone and tail circuits 24 hours a day, 7 days a week, and maintains statistics on network traffic and usage. Through proactive monitoring, the NOC identifies and repairs almost all circuit problems before the user is even aware that a problem exists. These operations problems are logged and tracked using an on-line database system that generates reports on performance and statistics.

NSI provides basic network connectivity to data archives, computational facilities, and collaborators worldwide, usually at 56 Kbps where feasible and appropriate. This service provides an open, reliable, shared network to assure mission success and includes connectivity for file transfer, electronic mail, and remote logon. It also includes value-added services, such as requirements definition, network engineering and consultation, network monitoring, and user information services. These services are provided at no cost to users whose requirements have been fully validated and prioritized by the sponsoring OSSA program, and conform to NSI's Acceptable Use Policy.

Special services provided by NSI include nonstandard installations and applications requiring specially engineered solutions and equipment, such as dedicated private lines between specific facilities, very-high-performance links, high performance

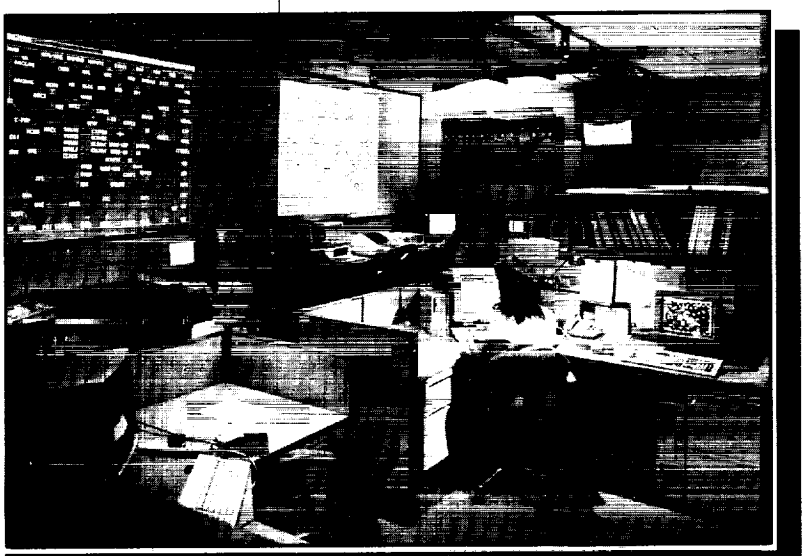


Figure 8:

The NOC operates and monitors the network 24 hours a day, 7 days a week

"Plans to deploy NREN's state-of-the-art cell relay architecture to support NASA's HPCC Earth and Space Science's Grand Challenge are already underway."

network applications, etc. Requests are considered on a case-by-case basis. Costs for these services depend on the nature of the service required and may require cost-sharing by the initiating user or project sponsor.

As of October 1992, over 2000 OSSA networking requirements have been submitted to NSI. Of that total, 1000 are completed, and the remaining 1000 are being processed. NSI's user community is represented by science discipline in Figure 9.

NSI installed 56 new sites on the network in FY 92. The network now contains approximately 163 tail sites and roughly the same number of routers. NSI is also now attached to the NSFNET at 45 Mbps (T3), and it implemented a new T1 service between JPL in Pasadena, California, and the National Center for Atmospheric Research in Boulder, Colorado. The higher throughput achieved from these upgrades increases scientists' access to OSSA's supercomputer facilities and allows them to access the large Earth and space science databases and computational facilities (Figure 10). In addition to increasing link bandwidths, the volume of traffic which can be handled by routers is also growing. It is NSI's goal to continue to capitalize on technology advances to offset the impact of increasing user demand.

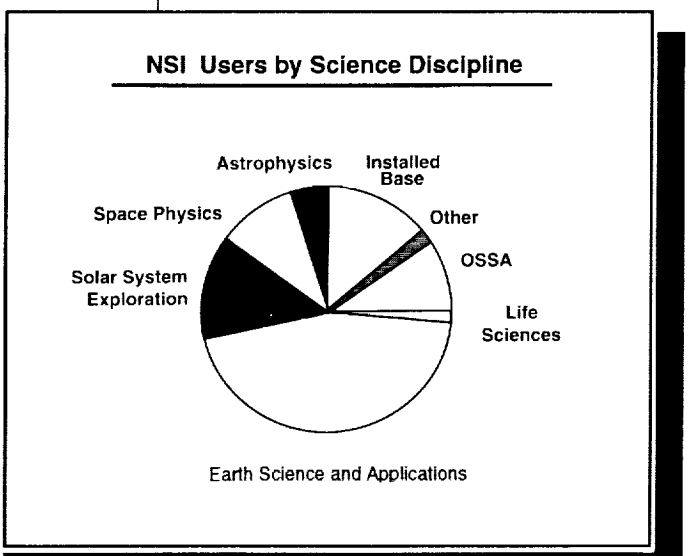


Figure 9:

NSI Supports a broad User Community

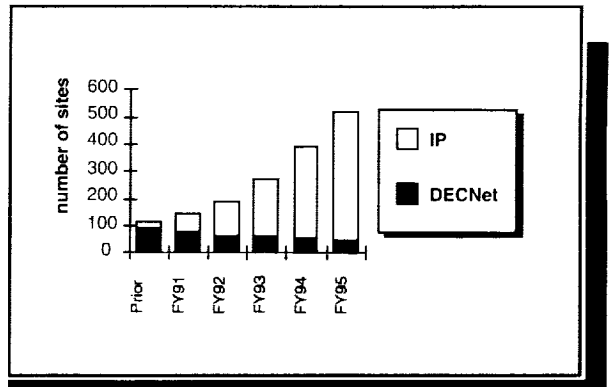


Figure 10:

Number of sites by fiscal year, projected out 5 years

NSI is a vital partner in the development of the National Research and Education Network (NREN) , a key component of the Federal High Performance Computing and Communications (HPCC) Program. NSI is participating in the design and specification of NREN technologies and will take full advantage of these technologies when they become commercially available for the benefit of its science community. Plans to deploy NREN's state-of-the-art cell relay architecture to support NASA's HPCC Earth and Space Science's Grand Challenge are already underway. When fully implemented, the NASA science and research community will be able to use 45-Mbps to 185 Mbps high-speed service at a fraction of the current runout cost.

To help define requirements and shorten the time required to meet them, NSI has implemented several new policies. NSI now provides coordination at the discipline and program levels in addition to supporting individual Principal Investigators. To shorten lead time, NSI is working to establish generalized, discipline-level Memorandums of Understanding (MOUs); specific MOUs can then be negotiated on a project-by-project basis within each discipline. NSI has also shortened processing time for requirements implementation by two to three months by streamlining its Network Service Request procedure. Hardcopy validation forms have been replaced with on-line versions to help shorten the response time by Headquarters validators and thus enable NSI to meet its user requirements faster. Due to its streamlined processing, NSI has completed over 200 requirements in FY92—30% more than in previous years. Because the growth in demand for network services continues to accelerate, NSI has also established a priority scheme based on program priorities and resources. As evidenced by the ever-growing demand for new connections, networking is now considered a critical component of OSSA science; NSI staff predict an explosion in network utilization in the coming years by all NASA scientists (Figure 11).

OSSA has accepted NSI's requirements-driven business approach and continuous-improvement methodology for best cost performance, and NSI has demonstrated the ability to satisfy its users' network needs. OSSA's continuing challenge to NSI is to provide a high-speed, open communications network service that connects all Earth and space scientists, providing ready access to data and information stored anywhere in the world.

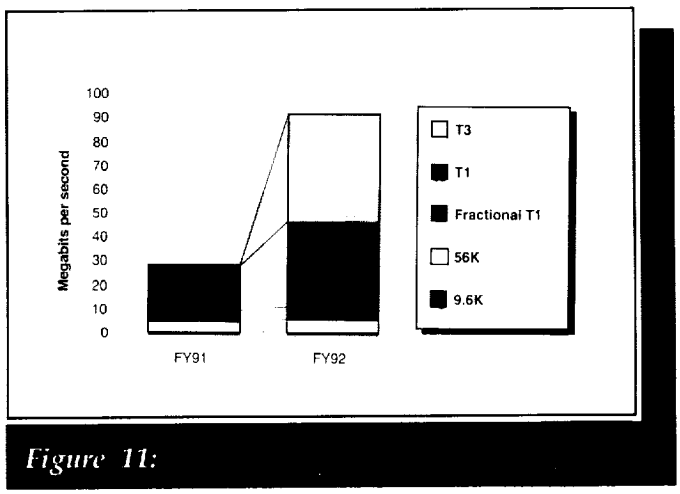


Figure 11:

NSI is moving to higher capacity links to support its users

Highlights

The OSSA Networking Program provides thousands of OSSA researchers with worldwide network services that have become vital to the conduct of today's distributed multidisciplinary science investigations. In addition to this broad community support, the program also supports some OSSA project specific activities, a networking outreach program, and scientific conferences of relevance to OSSA.

High Resolution Microwave Survey

In October 1992, NSI provided connectivity essential for the success of NASA's inauguration of High Resolution Microwave Survey (HRMS), its most ambitious program ever to find evidence of intelligent life in other star systems. NSI provided connectivity to the two radio telescopes used for the initial HRMS deployment: Goldstone Deep Space Communications Complex and the National Astronomy and Ionosphere Center's Arecibo Observatory in Puerto Rico. NSI also provided consulting help for this project by assisting the HRMS staff with UNIX system management, and network security, and use of Internet tools and facilities.

Antarctica

In January 1992, NSI, in cooperation with the Program Support Communications Network, implemented the world's first high-speed computer network link to Antarctica, providing both high-quality voice and high-speed data connectivity between the continental United States and the U.S. base at McMurdo Sound (Figure 12). This prototype communications link was subsequently expanded to provide 512 Kbps to support "telepresence technology" as a precursor for Mars remote exploration technology. In November 1992, the beginning of the Antarctic summer, NSI staff succeeded in setting up the first-ever video link between Antarctica and the continental United States to transmit video images between researchers at ARC and a Remotely Operated Vehicle maneuvering under ice-covered lakes in the Antarctic. This link is being tested over the Internet and monitored at ARC.

Figure 12:

NSI engineers install a video communications link on the Ross Ice Shelf, Antarctica, in preparation for the launch of the Remotely Operated Vehicle

Flight Project Support

Galileo:

NSI supplied a T1 (1.44 megabits per second) circuit to support the two-week Galileo display at the Smithsonian National Air and Space Museum as the spacecraft began its second Earth encounter in December 1992. Support required heavy use of the NSI/Galileo global electronic network for data sharing and distribution, as well as for rapid electronic communications. NASA and Museum officials produced a high-visibility public exhibit for this historic event including near-real-time Galileo data displays.

Upper Atmosphere Research Satellite:

The Upper Atmosphere Research Satellite (UARS) program required a "closed" DECnet network. In order to maintain network integrity, NSI engineers built a "spider" network centered at GSFC with dedicated lines for some nodes, and encapsulation for others. NSI engineers were successful in integrating several different network technologies to achieve a quality network architecture that met the project's requirements.

International Solar Terrestrial Physics:

NSI and the International Solar Terrestrial Physics (ISTP) program signed an MOU this spring to support multiple experiments dispersed globally for a total of 60 experiments from 6 missions flying 9 spacecraft in the solar terrestrial environment. The missions require a mixture of TCP/IP and DECNET. NSI works with the OSSA Space Physics Division, providing information about NSI's services and networking trends. NSI this year supported the launch of Geotail, part of the ISTP program, which was sponsored jointly with Japan's Institute of Space and Astronautical Sciences.

Conference Support

NSI's conference support allows scientists to maintain electronic contact with their science communities at home while they attend conferences and also allows them to conduct computer demonstrations at the conference. NSI supports NASA scientists at approximately six major scientific conferences a year providing networking support for activities ranging from e-mail to real-time visualization of space data. Scientists at the American Astronomical Society meeting in January 1992 were able to observe a supernova only four days after its discovery through images and data which were transmitted over the network from GSFC to the International Ultraviolet Explorer (IUE) booth at the conference.

MU-SPIN

The Minority University Space Interdisciplinary Network (MU-SPIN) Program is a major networking education initiative for Historically Black Colleges and Universities (HBCUs) and Minority Universities (MUs). The MU-SPIN Program focuses on wide area networking and its use for supporting multidisciplinary research. It is aimed at transferring networking technology to HBCUs and MUs through connectivity, training, research opportunities, a residence program, and a Users Working Group. In 1992, four MU-SPIN institutions obtained wide area network connectivity (Spellman, Clark Atlanta, Southern, and Morgan) and three are pending (Morris Brown, Fisk, and Tuskegee). Summer internships at GSFC were provided for two faculty and two students. Twelve faculty and students received network training at GSFC and 75 more obtained similar training at Tuskegee.

Data Management and Archiving

"policies, procedures, and systems to ensure the proper accessibility and preservation of OSSA science data"

The objective of the Data Management and Archiving program is to coordinate the development of OSSA data management and archiving policies, procedures, and systems to ensure the proper accessibility and preservation of OSSA science data. The program manages the NASA Master Directory, the National Space Science Data Center (NSSDC) at the Goddard Space Flight Center, the OSSA Data Management Initiative (DMI), and a data standards program.

A major milestone this year was the approval of the OSSA Data Management Policy. This policy defines the data management roles of the science disciplines and the OSSA Flight Systems Division. It also further strengthens the role of the Project Data Management Plan as a tool for ensuring the proper planning of data management activities throughout the life of the program and beyond.

A central component in OSSA's information systems environment is the NASA Master Directory. The Master Directory is an on-line information system for the rapid and efficient identification, location, and overview of data sets of interest to the science community. It provides active links to other catalogs and databases around the world, allowing OSSA researchers "one stop shopping" for science data. The number of entries in the Master Directory increased this year from 1118 to 1664; the directory now contains listings for nearly all OSSA data held in public archives. On-line access to the Master Directory has grown this year from roughly 500 to 800 accesses per month, indicating the increased community awareness and utility of this resource.

The NSSDC is OSSA's multidisciplinary repository for over 6 terabytes of science data in over 4400 data sets. This year, the NSSDC acquired 92 new data sets and 68 updated data sets to make available to the research community (see Figure 13). These came in the form of 2367 magnetic tapes, 62 CD-ROMs, 118 WORM optical disks, and some small amounts of film, microfilm, microfiche, and 35mm slides. The NSSDC is committed to providing easy access to and navigation through its holdings. The increased availability of science data on CD-ROM and on-line systems has led to an explosion in user access. The NSSDC responded to 6575

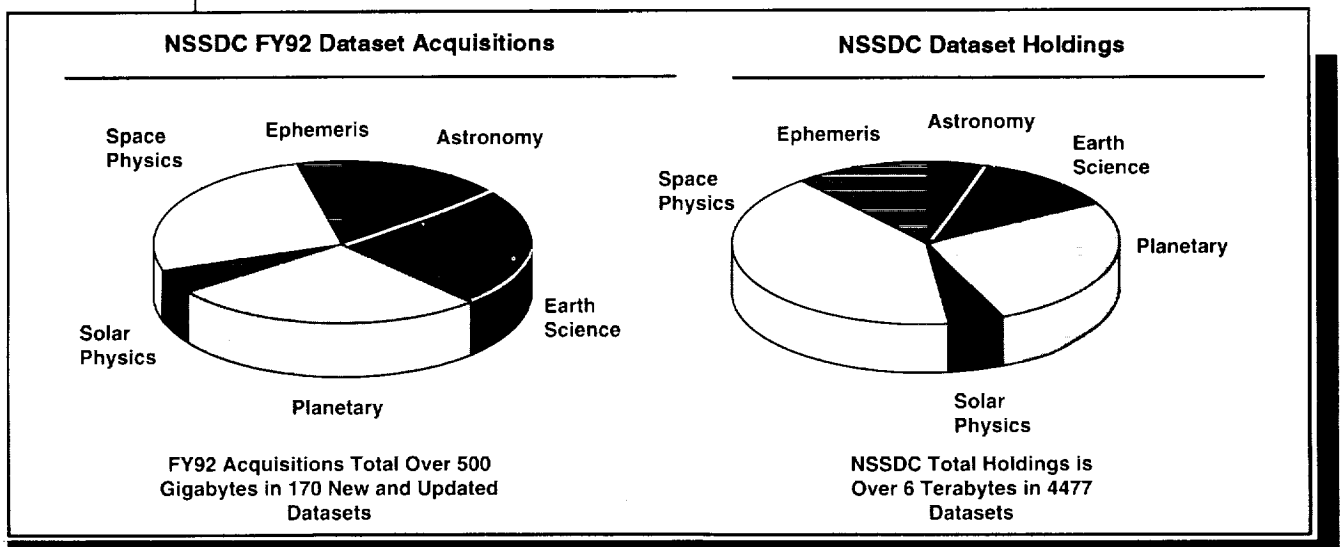


Figure 13:

NSSDC holdings are at 6 terabytes of OSSA science data, and growing!

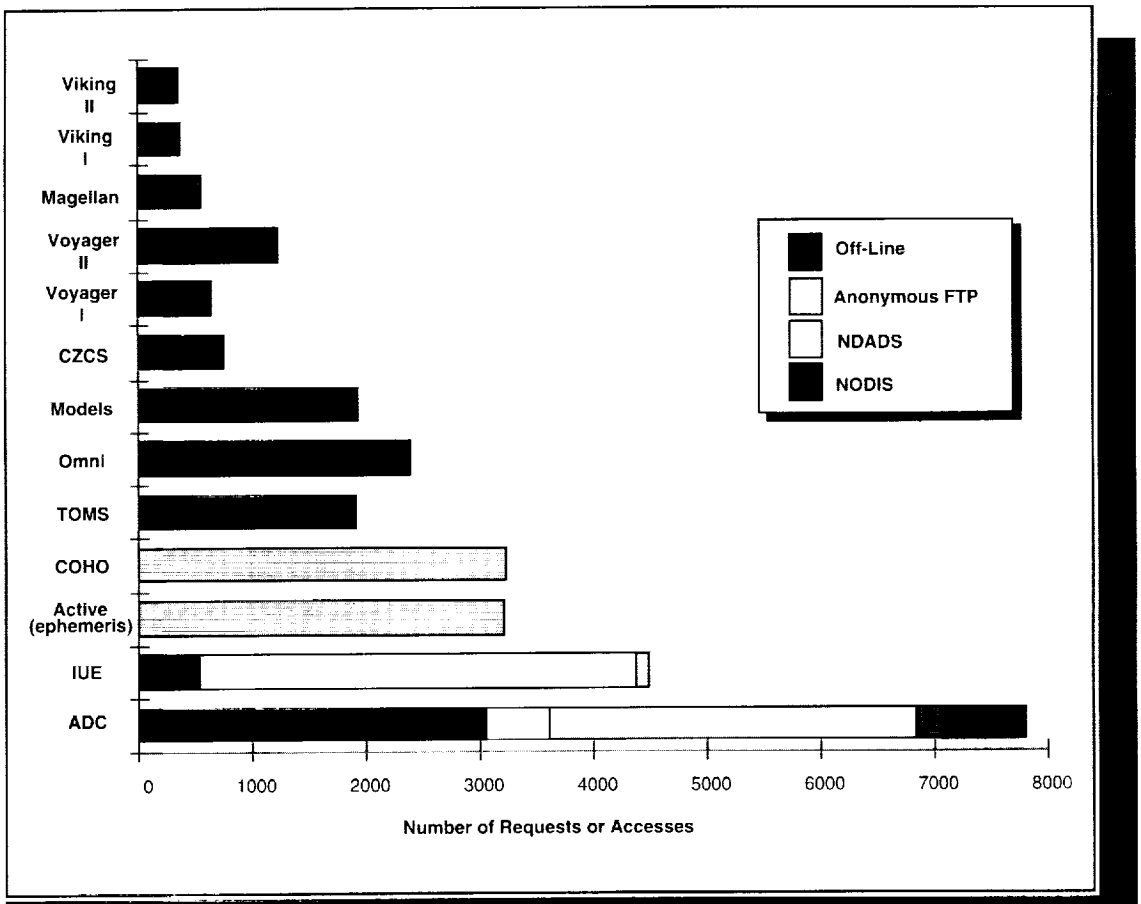


Figure 14:

Most Requested or Accessed NSSDC Data Sets

requests for hardcopy distribution, which resulted in the distribution of 18,000 CD-ROMs and 3400 9-track tapes. The NSSDC on-line data systems hosted over 55,000 sessions for the distribution of data and information. The most requested digital data sets are shown in Figure 14.

This year marked significant progress for the DMI. The DMI is intended to identify all extant OSSA mission data, evaluate media quality, prioritize data requiring restoration, and restore the subset of data that has continuing science value. In addition, the DMI will upgrade existing and planned discipline data management systems and the NSSDC so that they will be able to support effectively the increasing data volumes of the future. During 1992, the NSSDC moved data from 7766 magnetic tapes onto 1018 new data volume pairs (one 9-track tape and one 3480 tape cartridge). The total number of NSSDC tapes restored to date is 24,490, and 3740 new volume pairs have been created. There are approximately 40,000 not-yet-restored tapes created prior to 1984, some of which may not be good candidates for restoration. Similar efforts are underway at JPL and at several individual investigator sites. The DMI is also assisting the NASA Life Science and Microgravity Divisions establish discipline data systems to ensure the preservation and availability of their investigations products.

The Data Management and Archiving Program continues to sponsor the development and implementation of data formats and standards. The objective of these

services is to facilitate improvements in the effectiveness and interoperability of OSSA data systems. Requests for standards and related documents from the NASA/OSSA Office of Standards and Technology (NOST) and the NSSDC Standards and Technologies Information System (STIS) nearly doubled in 1992 to 2200 from 1384 in 1991. The content of the NOST Library (paper) and STIS files includes 177 standards and 549 related documents. This represents a doubling in 1992 of the number of standards managed and a 25% increase in the related documents. In addition, there were 71 requests to the NSSDC Flexible Image Transport Standard support office, which resulted in the distribution of 673 documents and software.

The OSSA-sponsored standards activity contributed significantly to the development of two standards that were formally reviewed and approved by NASA. The Consultative Committee for Space Data Systems (CCSDS) Standard Formatted Data Unit "Structure and Construction Rules" was recommended for labeling data. The CCSDS "Parameter Value Language" was recommended for expressing 'keyword = value' formatted data. OSSA projects that have voluntarily adopted one or both of these recommendations include ISTP, UARS, Pioneer 10 and 11, the Planetary Data System, the Solar Heliospheric Observatory, and the EOS Data and Information System Version 0 prototype.

Highlights

NSSDC Data Access and Distribution System

In January of 1992, the NSSDC's Data Access and Dissemination System (NDADS) became operational. NDADS is a network-accessible VAX cluster attached to optical disk jukeboxes with a combined capacity of 1.2 terabytes. Selected data sets have been loaded to the jukeboxes' disks, including astrophysics data from the International Ultraviolet Explorer, the Infrared Astronomy Satellite, and the High Energy Astrophysics Observatory-2; and space physics data from Skylab, the Dynamics Explorer, and the International Magnetospheric Explorer. User interest in these newly electronically accessible data has been significant, with recent monthly access rates running at 700 remote user sessions per month. Accessibility to archived data on time scales of minutes, rather than days or weeks, will greatly facilitate the process whereby scientists develop theories and then acquire and analyze data to test their hypotheses.

Data Distribution Laboratory

JPL's Data Distribution Laboratory provides support for scientists and engineers in the utilization of Compact Disk Read Only Memory (CD-ROM) and CD-Write Once technology for archiving and distributing scientific data sets. In its first two years of operation the lab has produced over 600 write-once CD-ROMs, including test CDs for the planetary programs Magellan, Galileo, Voyager, and Mars Observer, and supported other NASA disciplines, including astrophysics, climate and Earth sciences.

Laboratory equipment includes the latest CD recorders from major vendors and a variety of workstations that can be used to test CD productions on various platforms (PC, Macintosh, VAX, UNIX). In addition to CD production, the lab has performed research on CD media life, provided evaluations of both software and hardware needed for CD production, developed an illustrated catalog of scientific CD-ROM publications from all government agencies, and prototyped multimedia presentations of scientific publications.

Space Physics Sciences "Value-Added" Data Products and Data Accessibility Enhancements

OSSA, through the NSSDC and Space Physics Data Facility (SPDF), has sponsored the creation of a publicly accessible, on-line database for fields, and plasmas which will soon include energetic particle measurements from heliospheric spacecraft including Pioneer 10/11, Voyager 1/2, Helios, and Pioneer Venus Orbiter. The database has been updated this year in basic fields and plasma data and is showing a significant number of on-line accesses. NSSDC continues to maintain the OMNI database of near-earth field and plasma data as well.

The NSSDC is also now working to bring larger key space physics sciences data sets nearline (in NDADS). Data sets brought nearline this year include Skylab solar x-ray images, IMP-8 high-resolution magnetometer data. Future additions will include DE-1 auroral images plus other key DE-1 data. The Skylab data is additionally supported by a new PC-based image display tool for users, developed jointly in the SPDF and NSSDC.

Navigation and Ancillary Information Facility

The Navigation and Ancillary Information Facility (NAIF) at JPL continued to broaden its customer base in the planetary science community and in the other space science disciplines.

Having completed a successful launch, all Mars Observer science teams began using NAIF's ancillary information system called SPICE. Galileo teams used SPICE during the Gaspra and Earth-2 flybys and several groups associated with the Cassini mission began using SPICE technology to help evaluate the Saturn tour from a scientific standpoint. Observations of satellites from other spacecraft—including the Hubble Space Telescope and International Ultraviolet Explorer—and from terrestrial observatories were also successfully planned using SPICE.

Applications of SPICE in astrophysics, space physics, Earth sciences, and additional planetary programs are being studied. The list of potential projects to be supported includes Space Very Long Baseline Interferometry, Clementine, Satellite Test of the Equivalence Principal, Near Earth Asteroid Rendezvous, the Discovery Program Mission Set and EOS.

The Russian Space Agency has adopted the SPICE system and confirmed its intent to use SPICE for Mars 94/96, Radioastron, Spectrum-R/G, and Interbol. This decision will ensure that participating U.S. scientists will have access to the high-quality ancillary information needed to fully and properly interpret the scientific data returned from these spacecraft.

NOST Invitational Formats Workshop

The NOST held an Invitational Formats Workshop from 16-18 June 1992, in which key specialists in ten data formats discussed similarities, differences, and evolutionary directions. An immediate objective for this workshop was to further the production of a NOST data format comparison document, which will aid potential users in understanding and selecting formats appropriate to their needs. Another objective was to look for synergism among the data formats that could lead to some evolutionary convergence, or clarification of roles, so that future enhancements may be less duplicative and more interoperable.

Participants found the presentations informative, and several actions and collaborations were established. The success-

ful completion of these collaborations should significantly increase the ease of access to OSSA data by providing a better understanding of data formats and format conversions. It was clear that no discipline has all the answers and each can learn from the others. A key component of the process will be the establishment of additional mechanisms for obtaining broad community critiques to ensure future work meets the most important community needs.

Supporting the GGS/ISTP Project

The Information Systems Program has made critical data-management-related contributions to the Global Geospace Science (GGS) and the International Solar Terrestrial Physics (ISTP) programs by enabling better use of collected data to address the global-scale solar-terrestrial science problems. A joint effort between the SPDF and NSSDC is assisting these projects in the correct and most cost-effective use of key data standards, in supporting a master nearline data archive, and in developing and supplying key science planning software.

A major area of support is the GGS use of the Common Data Format (CDF) as a standard for Key Parameters (KPs). KPs are time-continuous data products characterizing the physical measurements of each instrument from every investigation at a resolution of approximately 10 parameters per minute. KPs are the key GGS mechanism supporting a "global" view of the data collected. In addition to ongoing extensions to generic CDF capabilities, SPDF and NSSDC have also developed a set of "implementation guidelines" for GGS that define a greater level of uniformity, laying a foundation that GGS can use to realize the desired global and holistic view of the data being collected.

A second key contribution to GGS will be to ingest and host the long-term KP database in NDADS. Software subsystems supporting data ingest and an interactive user interface have been developed this year. The system is now in initial operation with data being received. Work is underway to extend this convenient and powerful user interface to support a wide range of general archival data science users beyond the immediate GGS/ISTP project limits.

Study of Electronic Literature for Astronomical Research (STELAR)

The purpose of the STELAR project is to act as a pilot program for the electronic publishing and dissemination of scientific information, using astronomical literature as the test case. The current plan is to test electronic access to published literature by placing a useful fraction of the astronomical literature on-line. A useful fraction is defined to be the amount where most of the science queries could be satisfied within the sample. Thus the STELAR project is working towards creating bitmaps of five years worth of astronomical journals.

During this past year the STELAR project has made an initial test bitmap dataset of journals. These first tests are to evaluate the operational problems associated with bulk scanning a large volume of documents. Additionally, these tests have allowed the evaluation of the required scanning resolution and have given some practical experience with published photographic information. All of the collected information will be presented to the STELAR Planning Committee, as well as the publication officials and executive boards for the participating societies. If the initial tests are successful and the participating societies agree, the project will include the full astronomical community in its evaluations within the next two years. Through this pilot project the astronomical community will have the opportunity to explore the electronic publication of its most valuable resource, scientific literature.

Applied Information Systems Research and Technology

"to apply information systems technology as appropriate to improve support to OSSA science programs, and to enable the continual evolution of the OSSA data systems environment and supporting infrastructure."

The goals of the Applied Information Systems Research and Technology Program are to apply information systems technology as appropriate, to improve support to OSSA science programs, and to enable the continual evolution of the OSSA data systems environment and supporting infrastructure. The program is organized into three elements: applied research, technology development, and technology transfer.

This year, the applied research element of the program continued support for investigators in the Applied Information Systems Research Program (AISRP), at the Center for Excellence in Space Data and Information Systems (CESDIS), and in the Graduate Student Research Program. These investigations are designed to infuse computer and information systems science and technology from universities, government, and industry into the OSSA space science process through peer-reviewed research. Figure 15 illustrates the broad participation by different elements of the information science research community, which is a key to the success of the program.

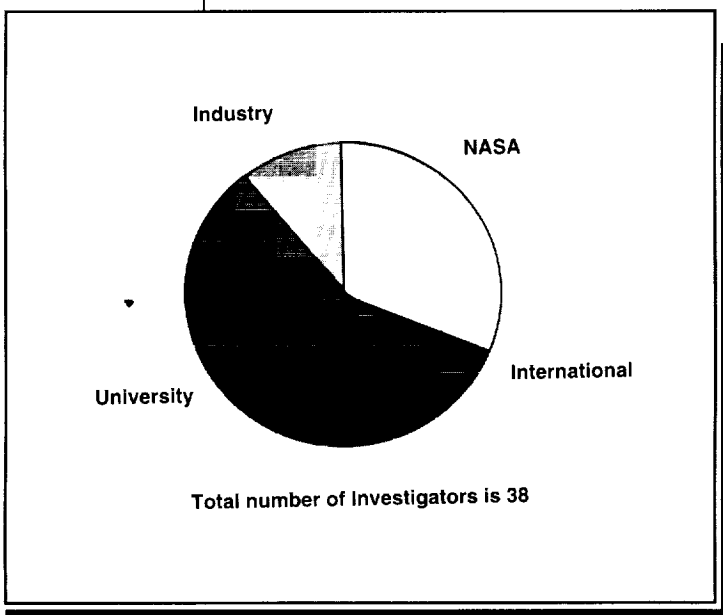


Figure 15:

The Applied Research and Technology Program supports a broad community of NASA, academic, and industry researchers

The second annual Applied Information Systems Research Program Workshop was held this year at the University of Colorado, Laboratory for Atmospheric and Space Physics. The purpose of this year's workshop was to evaluate the progress of current AISRP research projects and discern topics for new AISRP research to address OSSA science division needs. Participants included a broad spectrum of Earth, space, and computer scientists. During the formal sessions, investigators presented their current progress and future directions. In an adjacent area, several workstations were set up to run demonstrations during the breaks, which provided an opportunity for interaction among the attendees (Figure 16). This workshop helped to focus the goals and activities of the AISRP program and strengthened the partnership between Earth and space scientists and information systems technologists for the development of new tools and techniques.

The technology development element of the program enables the continual evolution of the OSSA data systems environment and supporting infrastructure through development and demonstration of science visualization tools, parallel software environments, data dissemination techniques, and other technology applications. The program supports several scientific visualization and analysis activities at JPL and GSFC.

The technology transfer element facilitates the testing, evaluation, insertion, and maintenance of current information systems technology into the OSSA space science program environment through the development of a technology transfer infrastructure. This infrastructure is just starting to be

realized, with work beginning at a software support laboratory located at the University of Colorado. This activity will expand to provide a capability for testbeds and demonstrations, software tools distribution, capturing user experience, and the development of test data suites.

Highlights

LinkWinds

The Linked Windows Interactive Data System (LinkWinds) allows a user to interactively link displays of data with various controls for manipulating that data (Figure 17). These links can be made at the discretion of the analyst and provide great flexibility in rapidly interacting with complex data to detect trends, correlations and anomalies. The LinkWinds data visualization system has been developed and tested using a variety of atmospheric, oceanographic, and geologic data sets. The system has produced results that are understandable and readily communicated to colleagues. An alpha test version has been completed and copies have been installed at a variety of sites, including the San Diego Supercomputer Center, Marshall Space Flight Center, Scripps Institution of Oceanography, and the University of Pittsburgh.

Current developments include a range of technical advances such as the incorporation of math analysis tools and animation capabilities. Extensive work is being done on a "real-time data mode" of LinkWinds which was used to support the Plasma Wave Spectrometer during the Earth-2 encounter of the Galileo spacecraft. When generalized, this mode will support the monitoring and analysis of space- and balloon-borne instruments, laboratory experiments, and computer simulations.

Solar System Visualization

The goal of the Solar System Visualization (SSV) activity is to reexplore the planets using data from previous NASA planetary missions and to create new tools and materials for science, education and public information. Major products from this activity include science analysis and visualization tools, and planetary science benchmarks used in evaluating new technologies. A series of science video products and CD-ROM perspective maps for each planet in the solar system except Pluto have been produced.

Figure 16:

Participants at the AISRP Workshop receive informal demonstrations from investigators.

In collaboration with the Ulysses Flight Team, SSV developed a model of the Ulysses spacecraft and created a simulation of the Ulysses encounter with Jupiter. This product was used by the Ulysses project and was released to the public during February 1992. SSV also developed an animation showing a series of simulated perspective views of the asteroid Gaspra. Galileo images of the asteroid were combined with a topographic model developed at Cornell and photoclinometry analysis done by the United States Geological Survey (USGS) to create the animation, which was used in the Galileo program and was released to the public in June 1992.

Two images of the surface of Venus were produced by the Solar System Visualization task in collaboration with the Magellan Science team using the Touchstone Delta supercomputer. The images are 3-D perspective views of Maat Mons and Sapas Mons, two interesting volcanoes located on the western edge of Alta Regio (Figure 18). These images were recently released in conjunction with the first anniversary of the installation of the Delta supercomputer at Caltech. The work is part of NASA's Grand Challenge research in the Planetary Science application of high performance computation.

A study of the dynamics and temperatures associated with ozone depletion is an ongoing research effort at NASA, Caltech and JPL. A video entitled "Global Ozone Concentration Movies, 1980-1990" was released in June. The video provides five views of global ozone concentrations derived from the Nimbus-7 Total Ozone Mapping Spectrometer instrument. Excerpts from this video were shown at the U.N. Conference on Environment and Development in Rio de Janeiro.

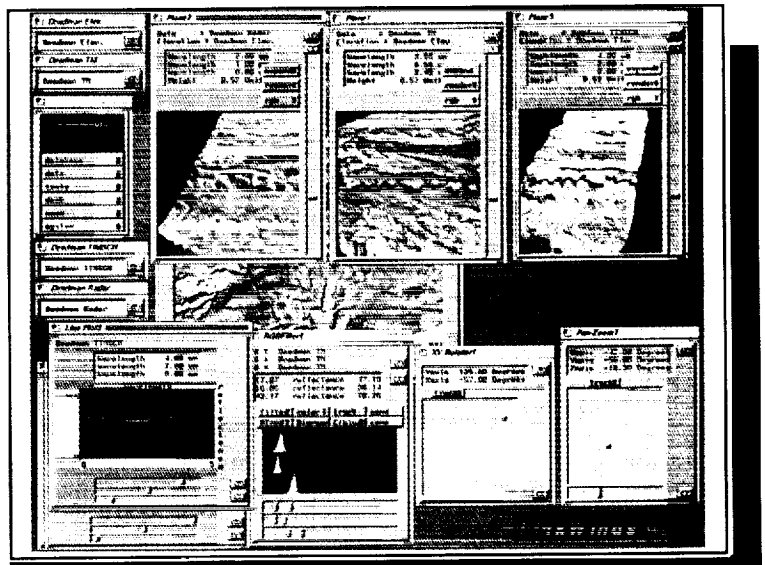


Figure 17:

LinkWinds provides a simple, intuitive interface for scientific data visualization

Surveyor

Surveyor is a three-dimensional data visualization system that runs in a heterogeneous distributed computing environment. Surveyor also provides inverse rendering capability, which can retrieve sensor data for selected areas in a rendered scene. This capability can be utilized as a user interface for the analysis of scientific data, such as geological databases.

Because of its emphasis on geological data, and because the distributed rendering architecture makes Surveyor easily extensible, a formal decision was made to incorporate Surveyor into the Casa gigabit network testbed experiment. Casa is part of the national HPCC program. Surveyor will be used as the user interface in a collaboration with a group of Earth scientists using spectral and seismic data to evaluate geologic information.

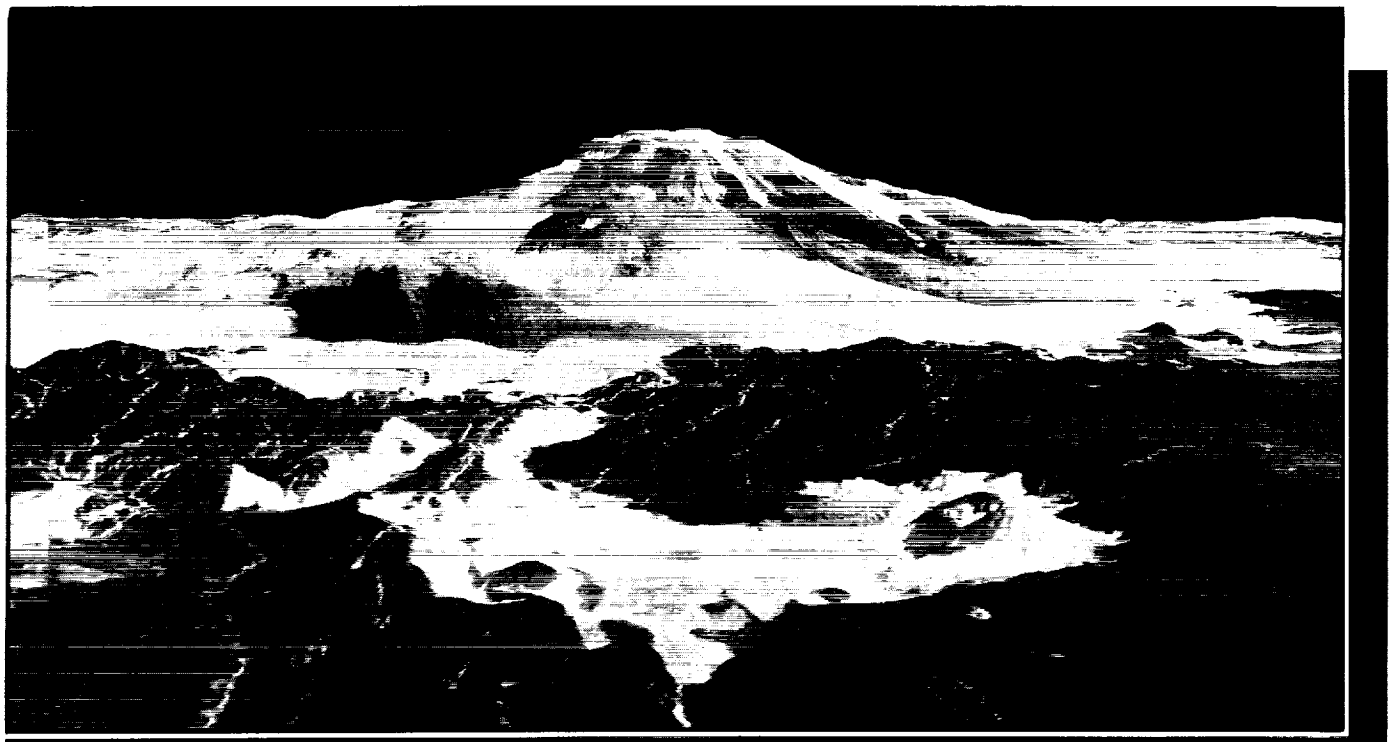


Figure 18:

This Magellan image of Maat Mons was rendered on a 64 processor Intel Touchstone Delta using software developed at JPL

In the past year, Surveyor has progressed from being a demonstration of a distributed rendering environment to being a functioning visualization and animation package. In addition, as part of the Casa project, a terrain renderer for the Touchstone Delta supercomputer has been integrated as a renderer under Surveyor and is currently being tested in that environment. Besides the Casa project, test copies of Surveyor have been installed at the USGS, Morgan State University, and various sites around JPL.

PLATO

The Planetary Analysis Tool Set (PLATO) is a UNIX-based set of object-oriented tools under development for rudimentary visualization, dynamic database selection, and low-level systematic processing of Planetary Data System CD-ROM datasets. PLATO fully supports Voyager data sets and provides browse and selection capabilities for the remaining Planetary Data System (PDS) datasets—Viking, Magellan, and Galileo.

The PLATO set currently runs under Open Windows on Sun computers. A test version is being evaluated under Motif on silicon graphics computers. Versions are being developed for NeXT and Macintosh computers. The tools are planned to be extended to the Mars Observer and EOS datasets as they become available. Test versions of the software have been distributed to Marshall Space Flight Center, Goddard Space Flight Center, USGS/ Flagstaff, University of California at Los Angeles, Caltech, and to various users at JPL.

Computer Assisted Analysis of Auroral Images

This activity was initiated to develop algorithms for the quantitative analysis of Dynamics Explorer-1 (DE-1) ultraviolet satellite images of the Earth's aurora. The Stanford University Project, funded by CESDIS, showed automatically generated inner and outer auroral oval boundaries for

16 DE-1 Satellite images applying computer-generated elastic curves techniques (Figure 19). The technology was transferred to the University of Iowa and NSSDC. A demonstration was conducted in July 1992 at NSSDC. Features demonstrated included an automatic algorithm that requires no user supervision, an interactive boundary editing system that allows manual modification of automatically generated boundaries, and a feature extraction system currently under development that allows intensity and shape features to be extracted from auroral images.

Previously applied standard image processing and computer vision techniques have failed to provide adequate performance with auroral images. Recovering inner and outer auroral boundaries provides an image description rich enough to allow many different measurements and parameters to be calculated. For example: the inner boundary allows determination of the magnetic field within the polar cap, a fundamental parameter needed by geophysicists to study the flow of energy through the solar wind-magnetosphere-ionosphere system. This technique can be used by the NSSDC to process auroral images currently being acquired. Additionally, the boundary-finding algorithm can be accessed remotely by the NDADS computer system. The interactive boundary editing system can be used in conjunction with other NSSDC software to visualize auroral data. There are also potential applications for the International Solar Terrestrial Physics (ISTP) community through the Laboratory for Extraterrestrial Physics.

Outreach

OSSA is involved in outreach activities that provide information and insight to the scientific and educational communities regarding its information systems progress.

One activity is the publication of the "Information Systems Newsletter." The purpose of the newsletter is to inform the science and applications research and technology community about information systems development and to promote coordination and collaboration by providing a forum for communication. Approximately 3000 people subscribe to the newsletter at NASA Centers, universities, and businesses in the U.S. and abroad. The newsletter received the Society for Technical Communications Award of Merit for clear writing style and design consistency. The newsletter continues to evolve by experimenting with electronic publication.

In addition to the regular reporting of technical developments in the newsletter, several OSSA information systems tasks have significant educational and public information implications. Navigation and Ancillary Information Facility (NAIF) data products and software are in use by graduate students at several universities. Many of the animations produced for scientific tasks have been used for educational purposes. Several of the products developed under the auspices of the Solar System Visualization activity have received wide coverage and presentation in the popular and scientific press.

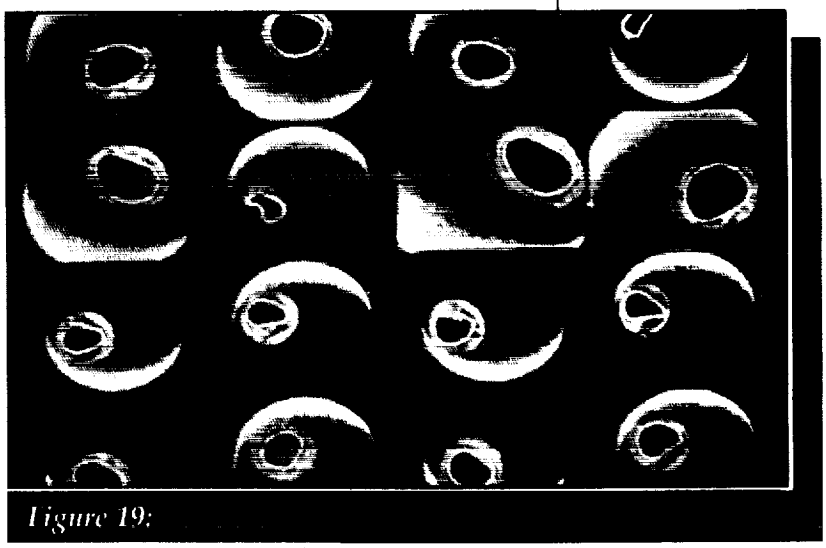
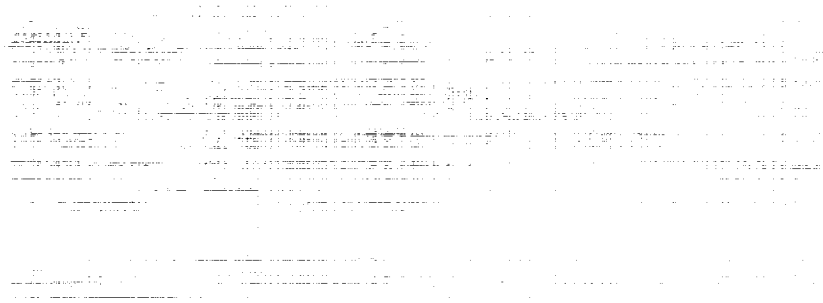


Figure 19:

These auroral images show the detection of the inner auroral boundary, a key parameter for the study of the energy flow associated with aurora



Acronyms

AAS	American Astronomical Society
AGU	American Geophysical Union
AISRP	Applied Information Systems Research Program
ARC	Ames Research Center
ATM	Asynchronous Transfer Mode
CCSDS	Consultative Committee for Space Data Systems
CD	Compact Disk
CD-ROM	Compact Disk - Read Only Memory
CDF	Common Data Format
CESDIS	Center for Excellence in Space Data and Information Systems
COSTR	Collaborative Solar Terrestrial Research
DDL	Data Distribution Laboratory
DE	Dynamics Explorer
DMI	Data Management Initiative
EOS	Earth Observing System
ESNET	Department of Energy Network
ESS	Earth and Space Sciences
FDDI	Fiber Distributed Data Interface
FITS	Flexible Image Transport Standard
GGS	Global Geospace Science
GSFC	Goddard Space Flight Center
HBCUs	Historically Black Colleges and Universities
HEAO	High Energy Astrophysics Observatory
HPCC	High Performance Computing and Communications
HRMS	High Resolution Microwave Survey
IMP	International Magnetospheric Explorer
IP	Internet Protocol
IRAS	Infrared Astronomy Satellite
ISTP	International Solar Terrestrial Physics
IUE	International Ultraviolet Explorer
JGM	Joint Gravity Model
JPL	Jet Propulsion Laboratory
KP	Key Parameters
LAN(s)	Local Area Network(s)
LinkWinds	Linked Windows Interactive Data System
MDSDS	Mass Data Storage and Distribution System
MOU	Memorandum of Understanding
MU	Minority University
MU-SPIN	Minority University Space Interdisciplinary Network
NAIF	Navigation and Ancillary Information Facility
NASA	National Aeronautics and Space Administration
NCCS	NASA Center for Computational Sciences
NDADS	NSSDC's Data Archive and Dissemination System
NOS	Network Operations Center
NOST	NASA/OSSA Office of Standards and Technology
NREN	National Research and Education Network
NSFNET	National Science Foundation Network
NSI	NASA Science Internet

NSR	Network Service Request
NSSDC	National Space Science Data Center
OSSA	Office of Space Science and Applications
PC	Personal Computer
PDS	Planetary Data System
PLATO	Planetary Analysis Tool Set
SETI	Search for Extraterrestrial Intelligence
SGCCP	Stratospheric General Circulation with Chemistry Project
SONET	Synchronous Optical Network
SPDF	Space Physics Data Facility
SSV	Solar System Visualization
STELAR	Study of Electronic Literature for Astronomical Research
STIS	Standards and Technologies Information System
TCP/IP	Transport Control Protocol/Internet Protocol
TOPEX	Ocean Topography Experiment
TOS	The Oceanography Society
UARS	Upper Atmosphere Research Satellite
UCLA	University Californian Los Angeles
USGS	United States Geological Survey
WORM	Write Once Read Many

For Further Information

OSSA Information Systems Branch

The OSSA Information Systems Branch provides a multidisciplinary information systems services infrastructure to support the research and analysis goals of the discipline divisions; coordinates the OSSA-wide integration of information systems activities; and maintains awareness of and applies new and innovative technologies to improve support to OSSA science endeavors. The Information Systems Branch functions as a service organization providing support to OSSA discipline programs and to the OSSA science research community. The people listed below lead the coordination of OSSA efforts in the respective areas, and may be contacted for further information.

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About the Cover

The cover image represents the goal of the information systems program to provide an environment that combines network access to multidisciplanary data archives and computational resources with scientific visualization and analysis tools. The program brings together information systems technologists and Earth and space scientists in collaborations to support OSSA's research objectives. The windowed images are taken from the body of the report and are described in the text.

The original cover layout conceptual design was developed at JPL using the LinkWinds visualization tool. The image was transferred from JPL via NASA Science Internet using anonymous file transfer to CSAT and combined with other digital and hardcopy artwork.

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